SOFTWARE TECHNOLOGY FOR ADAPTABLE, RELIABLE SYSTEMS (STARS) PROGRAM

Mapping of Cleanroom Against the CMM: Capability Maturity Model for Software Goals Mapped to Cleanroom Software Engineering Process

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This document provides the results of an evaluation of the levels of conformance of the Cleanroom Software Engineering (CSE) process with the Capability Maturity Model (SW-CMM) for Software, v1.1, Goals. The Goals for each SW-CMM level and KPA are listed and the level of conformance is indicated as outlined in the following descriptions:

    High – CSE addresses the goal to a very high degree.
    Medium – CSE addresses the goal to a partial degree.
    Low – CSE addresses the goal in a very minimal fashion.
    None – CSE does not address the goal to any degree.

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Capability Maturity Model for Software Goals Mapped to Cleanroom Software Engineering Process

by Paul G. Arnold

Introduction   This document provides the results of an evaluation of the level of conformance of the Cleanroom Software Engineering (CSE) process with the Capability Maturity Model (SW-CMM) for Software, v 1.1, Goals. The Goals for each SW-CMM level and KPA are listed and the level of conformance is indicated as outlined in the following description.

Degree of Conformance   The degree to which CSE addresses the goals as set forth in the SW-CMM.

Level of Conformance with the SW-CMM	Descriptive
CSE addresses the goal to a very high degree. The method of addressing the goal is not important but the end result must address the goal in substantial fashion.	**High**
CSE addresses the goal to a partial degree. The end result must address the goal whether a direct or indirect requirement of the CSE.	**Medium**
CSE addresses the goal in a very minimal fashion and is not a direct requirement of the CSE process.	**Low**
CSE does not address, or is not applicable to this goal to any degree.	**None**

Basis   This analysis takes into account the work performed for the detailed mapping of CSE to the SW-CMM using the Cleanroom Process Guide and Model, SEI Process Asset Library, v2, as the Cleanroom source document. The SEI Software Process Framework was the source document for SW-CMM compliance.

Credits   This version reflects comments to the original document of June 7, 1995 from reviewers Richard Linger and S. Wayne Sherer, and comments from the October 11, 1995 version from reviewers William H. Ett and S. Wayne Sherer.

Summary of Results

Both the SW-CMM Goal analysis and the detailed mapping of the SW-CMM recommendations against the CSE process provided a picture of a well defined process that is highly consistent with the SW-CMM. In areas where CSE is SW-CMM deficient, concerns can be addressed by extending the process definition to include these areas without causing serious compromise of basic CSE principles.

CSE has a consistent SW-CMM deficiency that is based upon its project centered view with all tasks performed by project teams. This leads to three main areas of non compliance:

- CSE does not include the larger concept of organization. The project view within CSE is highly developed and would easily lend itself to extension at the organizational level. CSE compliance with the organizational recommendations of the SW-CMM would not destroy or alter CSE concepts and would be easy to add to the definition. There are a number of KPAs where the organizational planning/support is deficient because it is not addressed by CSE.

- CSE does not include a large amount of the managment activities as recommended by the SW-CMM.

- CSE does not include an independent Software Quality Assurance group since this function is largely performed by CSE project teams. CSE does incorporate to a very high degree the checks and reports required by the SQA KPA in the form of team reviews. The addition of an independent SQA group would satisfy the CMM.

CSE does not address the following KPAs:

- Software Configuration Management (Level 2) concerns in the area of software baselines. However, CSE work products are identified and controlled on an on-going basis within a project by the Certification team. Others areas of control are not addressed, i.e. during specification and development.

- Software Subcontractor Management goals (Level 2). CSE does not address issues of management but how software is developed. CSE developed specifications for work products to be produced by Subcontractors would be of a very high quality and exactness in what was required.

- Technology Change Management goals (Level 5). CSE does not address this KPA which is more properly addressed by the organization for the benefit of all projects.

CSE in general does not address management issues, provide well defined roll descriptions or define a wide range of metrics important to the improvement of the process. These issues will be discussed in greater detail in the report on the detailed mapping of SW-CMM to CSE..

Assumptions   CSE is one of the processes supported by the organization.

Organizational planning/support services are available to CSE projects.

**Graphical
Summary of
Results**

CMM Goal Compliance of Cleanroom
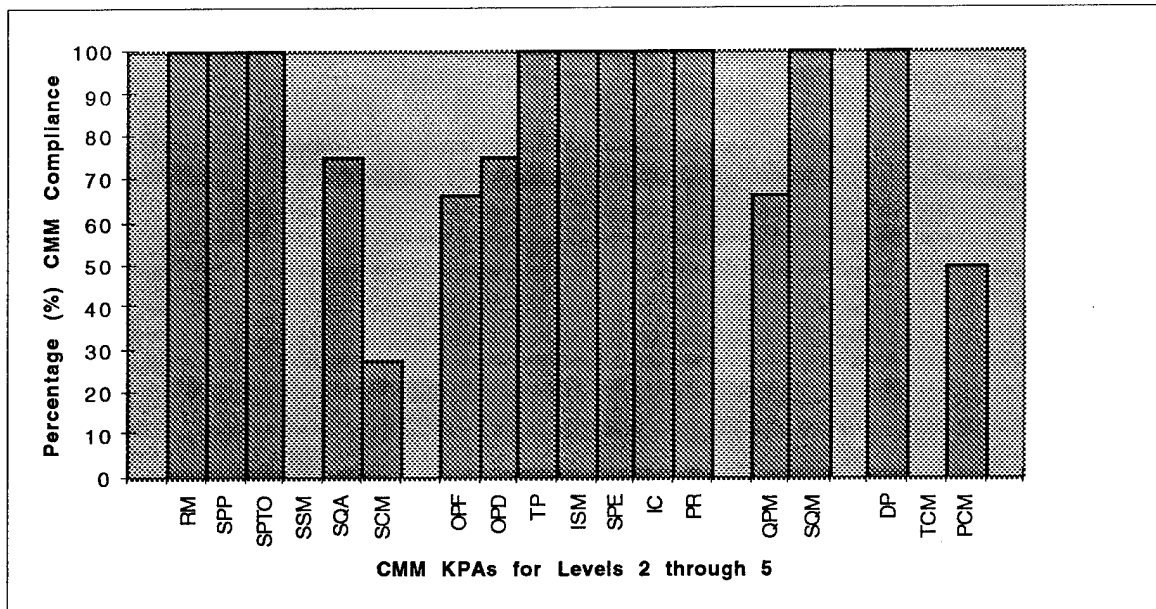
**Graphical
Chart
Construction**

The percentage (%) CMM Compliance on the above chart was determined by use of the following formula:

For each CMM Goal assign values as follows:

100% for High
50% for Medium
10% for Low
0% for None

Sum all values for a given KPA and divide by the number of goals for the given KPA.

Requirements Management

Purpose   to establish a common understanding between the customer and the software project of the customer's requirements that will be addressed by the software project.

SW-CMM Goal Conformance   The extent to which the goals of the Requirement Management KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	System requirements allocated to software are controlled to establish a baseline for software engineering and management use.	**High**
Goal 2	Software plans, products, and activities are kept consistent with the system requirement allocated to software.	**High**

Reference   Capability Maturity Model for Software, Version 1.1, page L2-2

Comments   CSE supports this KPA to a high degree with the only deficiencies in the areas of organizational process definition and an independent SQA group review. CSE requires Requirements Management as a fundamental part of the method, whether it is an organizational process or not. The team reviews required for all work products for this KPA could easily include an independent SQA monitor to comply with SW-CMM recommendations.

Software Project Planning

Purpose	to establish reasonable plans for performing the software engineering and for managing the software project.

SW-CMM Goal Conformance	The extent to which the goals of the Software Project Planning KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	Software estimates are documented for use in planning and tracking the software project.	**High**
Goal 2	Software project activities and commitments are planned and documented.	**High**
Goal 3	Affected groups and individuals agree to their commitments related to the software project.	**High**

Reference	Capability Maturity Model for Software, Version 1.1, page L2-12

Comments	CSE supports this KPA to a high degree with the only deficiencies in the area of organizational process definition. CSE requires Software Project Planning as a fundamental part of the method, whether it is an organizational process or not.

Software Project Tracking and Oversight

Purpose   to provide adequate visibility into actual progress so that management can take effective actions when the software project's performance deviates significantly from the software plans.

SW-CMM Goal Conformance

The extent to which the goals of the Software Project Tracking and Oversight KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	Actual results and performance are tracked against the software plans.	**High**
Goal 2	Corrective actions are taken and managed to closure when actual results and performance deviate significantly from the software plans.	**High**
Goal 3	Changes to software commitments are agreed to by the affected groups and individuals.	**High**

Reference   Capability Maturity Model for Software, Version 1.1, page L2-30

Comments   CSE supports this KPA to a high degree with the only deficiencies in the area of SQA group review and organizational overview.

Software Subcontractor Management

Purpose   to select qualified software subcontractors and manage them effectively.

SW-CMM Goal Conformance   The extent to which the goals of the Software Subcontractor Management KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	The prime contractor selects qualified software subcontractors.	**None**
Goal 2	The prime contractor and the software subcontractor agree to their commitments to each other.	**None**
Goal 3	The prime contractor and the software subcontractor maintain ongoing communications.	**None**
Goal 4	The prime contractor tracks the software subcontractor's actual results and performance against its commitments.	**None**

Reference   Capability Maturity Model for Software, Version 1.1, page L2-44

Comments   CSE use of Black Box specifications could be used as an excellent communications and compliance document with subcontractors. This specification is unambiguous and provides excellent documentation on requirements for statement of work and software development tasks.

CSE does not have a process that addresses this area of the SW-CMM.

Software Quality Assurance

Purpose to provide management with appropriate visibility into the process being used by the software project and of the products being built.

SW-CMM Goal Conformance The extent to which the goals of the Software Quality Assurance KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	Software quality assurance activities are planned.	**High**
Goal 2	Adherence of software products and activities to the applicable standards, procedures, and requirements is verified objectively.	**Medium**
Goal 3	Affected groups and individuals are informed of software quality assurance activities and results.	**High**
Goal 4	Noncompliance issues that cannot be resolved within the software project are addressed by senior management.	**Medium**

Reference Capability Maturity Model for Software, Version 1.1, page L2-60

Comments CSE does not define a separate group whose sole function is SQA activities. CSE does, however, incorporate to a high degree the checks and reports required by this KPA in the form of team reviews.

The addition of an independent SQA group representative for all CSE team reviews would satisfy the CMM goals for this KPA.

Software Configuration Management

Purpose   to establish and maintain the integrity of the products of the software project throughout the project's software life cycle.

SW-CMM Goal Conformance   The extent to which the goals of the Software Configuration Management KPA are addressed by the CSE process:

	Description from SW-CMM	**Cleanroom Conformance**
Goal 1	Software configuration management activities are planned.	**Low**
Goal 2	Selected software work products are identified, controlled, and available.	**Medium**
Goal 3	Changes to identified software work products are controlled.	**Medium**
Goal 4	Affected groups and individuals are informed of the status and content of software baselines.	**None**

Reference   Capability Maturity Model for Software, Version 1.1, page L2-72

Comments   CSE does not have a process that addresses this area of the SW-CMM and does not address software baselines. However, CSE work products are identified and controlled on an on-going basis within the project by the Certification team. SCM is a required addition for project wide use by all the teams practicing CSE as proscribed by an organizational process.

Organizational Process Focus

Purpose   to establish the organizational responsibility for software process activities that improve the organization's overall software process capability.

SW-CMM Goal Conformance   The extent to which the goals of the Organizational Process Focus KPA are addressed by the CSE process:

Description from SW-CMM	Cleanroom Conformance
Goal 1 — Software process development and improvement activities are coordinated across the organization.	**Medium**
Goal 2 — The strengths and weaknesses of the software processes used are identified relative to a process standard.	**High**
Goal 3 — Organization-level process development and improvement activities are planned.	**Medium**

Reference   Capability Maturity Model for Software, Version 1.1, page L3-1

Comments   CSE supports this KPA from a partial to high degree with the only deficiencies in the area of generic organizational process support. CSE already collects data on the quality of products being produced. This data collection would require augmentation with additional process and product quality metrics to produce a more detailed picture of performance. Adding organizational structure to provide for a centralized cross project data collection, analysis and process improvement effort would largely satisfy SW-CMM deficiencies for this KPA.

CSE maintains a project focus that does not preclude the process from being included in the organization process baseline. The organizational process baseline should include CSE processes and practices.

Organizational Process Definition

Purpose to develop and maintain a usable set of software process assets that improve process performance across the projects and provide a basis for cumulative, long-term benefits to the organization.

SW-CMM Goal Conformance The extent to which the goals of the Organizational Process Definition KPA are addressed by the CSE process:

Description from SW-CMM	Cleanroom Conformance
Goal 1 A standard software process for the organization is developed and maintained.	**Medium**
Goal 2 Information related to the use of the organization's standard software process by the software projects is collected, reviewed, and made available.	**High**

Reference Capability Maturity Model for Software, Version 1.1, page L3-12

Comments CSE supports this KPA to a partial degree with the only deficiencies in the area of generic organizational process support. CSE would need the following to satisfy SW-CMM deficiencies for this KPA:

- Organizational adopton of generic process description

- Organizational adopton of measurement/metric collection data store

- Organizational adopton of process improvement based upon experience, lessons learned and analysis of measurement data across the various projects

CSE defines a generic process description that is tailored to a specific project. Tailoring adds project specific information to the generic process description.

CSE currently collects, reviews and analyzes data on a project by project basis. It is not a goal of CSE to define processes, but to follow them.

Training Program

Purpose
to develop the skills and knowledge of individuals so they can perform their roles effectively and efficiently.

SW-CMM Goal Conformance
The extent to which the goals of the Training Program KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	Training activities are planned.	High
Goal 2	Training for developing the skills and knowledge needed to perform software management and technical roles is provided.	High
Goal 3	Individuals in the software engineering group and software related groups receive the training necessary to perform their roles.	High

Reference
Capability Maturity Model for Software, Version 1.1, page L3-25

Comments
CSE doesn't address the training requirement as part of the defined process but as part of the preparation required before a CSE project could start. The training focus is limited to the area required to perform CSE tasks. The main area of deficiency is in organizational planning/support and in integrating this training into the defined process.

Integrated Software Management

Purpose   to integrate the software engineering and management activities into a coherent, defined software process that is tailored from the organization's standard software process and related process assets, which are described in Organization Process Definition.

SW-CMM Goal Conformance   The extent to which the goals of the Integrated Software Management KPA are addressed by the CSE process:

Description from SW-CMM	Cleanroom Conformance
Goal 1 The project's defined software process is a tailored version of the organization's standard software process.	**High**
Goal 2 The project is planned and managed according to the project's defined software process.	**High**

Reference   Capability Maturity Model for Software, Version 1.1, page L3-38

Comments   CSE supports this KPA to a high degree with the only deficiencies in the areas of organizational planning/support. CSE does not address the organizational level, only the project level.

Software Product Engineering

Purpose	to consistently perform a well-defined engineering process that integrates all the software engineering activities to produce correct, consistent software products effectively and efficiently.

SW-CMM Goal Conformance	The extent to which the goals of the Software Product Engineering KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	The software engineering tasks are defined, integrated, and consistently performed to produce the software.	**High**
Goal 2	Software work products are kept consistent with each other.	**High**

Reference	Capability Maturity Model for Software, Version 1.1, page L3-60

Comments	CSE supports this KPA to a high degree with the only deficiencies in the areas of organizational planning/support and traditional testing.
	CSE uses stepwise refinement, functional verification, and peer reviews to eliminate the need for debugging. Integration testing and system testing are accomplished through a process called Certification that uses a statistical Usage Profile to focus the "testing". This difference in approach to accomplishing the same end objective, error free software at delivery to the customer, is considered compliant with the SW-CMM.

Intergroup Coordination

Purpose   to establish a means for the software engineering group to participate actively with the other engineering groups so the project is better able to satisfy the customer's needs effectively and efficiently.

**SW-CMM
Goal
Conformance**

The extent to which the goals of the Intergroup Coordination KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	The customer's requirements are agreed to by all affected groups.	**High**
Goal 2	The commitments between the engineering groups are agreed to by the affected groups.	**High**
Goal 3	The engineering groups identify, track, and resolve intergroup issues.	**High**

Reference   Capability Maturity Model for Software, Version 1.1, page L3-84

Comments   CSE supports this KPA to a high degree by the use of the team approach to all reviews. CSE defines a roll for interaction with the customer before the job is accepted to address the questions of clarification of requirements, changes to requirements and accepting responsibility for requirements/changes at each stage of software development.

Peer Reviews

Purpose   to remove defects from the software work products early and efficiently. An important corollary effect is to develop a better understanding of the software work products and of defects that might be prevented.

SW-CMM Goal Conformance   The extent to which the goals of the Peer Review KPA are addressed by the CSE process:

	Description from SW-CMM	Cleanroom Conformance
Goal 1	Peer review activities are planned.	High
Goal 2	Defects in the software work products are identified and removed.	High

Reference   Capability Maturity Model for Software, Version 1.1, page L3-93

Comments   CSE supports this KPA to a high degree. There are no deficiencies in SW-CMM compliance for this KPA.

Quantitative Process Management

Purpose   to control the process performance of the software project quantitatively. Software process performance represents the actual results achieved from following a software process.

SW-CMM   The extent to which the goals of the Quantitative Process Management
Goal   KPA are addressed by the CSE process:
Conformance

Description from SW-CMM	Cleanroom Conformance
The quantitative process management activities are planned.	Medium
The process performance of the project's defined software process is controlled quantitatively.	Medium
The process capability of the organization's standard software process is known in quantitative terms.	High

Goal 1 — The quantitative process management activities are planned. — Medium

Goal 2 — The process performance of the project's defined software process is controlled quantitatively. — Medium

Goal 3 — The process capability of the organization's standard software process is known in quantitative terms. — High

Reference   Capability Maturity Model for Software, Version 1.1, page L4-2

Comments   CSE supports this KPA from a partial to a high degree and provides a foundation to support this KPA's activities. CSE requires the addition of quantitative and quality standards for assessing process efforts. CSE statistical testing does not address statistical evaluation of the process execution or its results.

Aside from these deficiencies, there is no support for the organizational generic CSE model, passing data collected to an organization based analysis and process improvement group or the setting up of an independent SQA group. These activities, all at the organizational level, are not precluded by CSE but are included as part of the planning/support services available from the organization.

Software Quality Management

Purpose   to develop a quantitative understanding of the quality of the project's software products and achieve specific quality goals.

SW-CMM Goal Conformance   The extent to which the goals of the Software Quality Management KPA are addressed by the CSE process:

Description from SW-CMM	Cleanroom Conformance
The project's software quality management activities are planned.	High
Measurable goals for software product quality and their priorities are defined.	High
Actual progress toward achieving the quality goals for the software products is quantified and managed.	High

Goal 1 — The project's software quality management activities are planned. — High

Goal 2 — Measurable goals for software product quality and their priorities are defined. — High

Goal 3 — Actual progress toward achieving the quality goals for the software products is quantified and managed. — High

Reference   Capability Maturity Model for Software, Version 1.1, page L4-20

Comments   CSE supports this KPA to a high degree and provides a good basic foundation to support this KPA's activities.

The main deficiency is in supporting the organizational generic CSE model by passing data collected to an organization based analysis and process improvement group and the setting up of an independent SQA group. These activities, all at the organizational level, are not precluded by CSE but are included as part of the planning/support services available from the organization.

Defect Prevention

Purpose   to identify the cause of defects and prevent them from recurring.

SW-CMM Goal Conformance   The extent to which the goals of the Defect Prevention KPA are addressed by the CSE process:

Description from SW-CMM	Cleanroom Conformance
Defect prevention activities are planned.	High
Common causes of defects are sought out and identified.	High
Common causes of defects are prioritized and systematically eliminated.	High

(Goal 1, Goal 2, Goal 3 correspond to the three rows above.)

Reference   Capability Maturity Model for Software, Version 1.1, page L5-2

Comments   CSE supports this KPA to a high degree and provides a good basic foundation to support this KPA's activities. The main deficiency is in organizational planning/support and the setting up of an independent SQA group.

CSE has a strong component in this area to collect, analyze, identify and prevent errors before they happen. In addition CSE techniques are geared towards developing code that is free of defects during the specification and development phases of software engineering.

Technology Change Management

Purpose   to identify new technologies (i.e. tools, methods, and processes) and track them into the organization in an orderly manner.

SW-CMM Goal Conformance   The extent to which the goals of the Technology Change Management KPA are addressed by the CSE process:

Description from SW-CMM	Cleanroom Conformance
Goal 1 — Incorporation of technology changes are planned.	None
Goal 2 — New technologies are evaluated to determine their effect on quality and productivity.	None
Goal 3 — Appropriate new technologies are transferred into normal practice across the organization.	None

Reference   Capability Maturity Model for Software, Version 1.1, page L5-18

Comments   CSE does not have a process that addresses this area of the SW-CMM.

This KPA is really not relevant to the practice of CSE. It is an organizational concern and should be supported from that perspective.

Process Change Management

Purpose   to continually improve the software processes used in the organization with the intent of improving software quality, increasing productivity, and decreasing the cycle time for product development.

SW-CMM Goal Conformance   The extent to which the goals of the Process Change Management KPA are addressed by the CSE process:

Description from SW-CMM	Cleanroom Conformance
Continuous process improvement is planned.	**Medium**
Participation in the organization's software process improvement activities is organization wide.	**Medium**
The organization's standard software process and the projects' defined software processes are improved continuously.	**Medium**

Goal 1 — Continuous process improvement is planned. — Medium

Goal 2 — Participation in the organization's software process improvement activities is organization wide. — Medium

Goal 3 — The organization's standard software process and the projects' defined software processes are improved continuously. — Medium

Reference   Capability Maturity Model for Software, Version 1.1, page L5-32

Comments   CSE supports this KPA by providing basic support for this KPA's activities at the project level. The main deficiency is in organizational planning/support and the setting up of an independent SQA group.

CSE has a strong component in this area to collect, analyze, identify and prevent errors before they happen. This data is used to improve upon the activities of the process at the project level if they are found to be responsible for the introduction of errors or the improvement of efficiency.